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**BEFORE THE**
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**"U.S. DEPARTMENT OF ENERGY'S**
**CLIMATE CHANGE TECHNOLOGY PROGRAM**
**STRATEGIC PLAN"**

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## INTRODUCTION

Madam Chairman and Members of the Subcommittee, thank you for the opportunity to appear before you today and report on the Climate Change Technology Program (CCTP). I am particularly pleased to be able to use the occasion of this hearing to announce the release of CCTP's completed *Strategic Plan*. It represents the culmination of strong interagency effort, shaped by expert technical input and public comment.

I would like to begin my testimony by providing a brief overview of the Administration's approach to climate change, which provides the context in which CCTP operates. I will also discuss the role of CCTP, explain the purpose of the *Strategic Plan*, and discuss how the *Plan* will help the Administration and Congress make decisions about investments in advanced technologies that can have a significant impact on reducing greenhouse gas emissions.

As a party to the United Nations Framework Convention on Climate Change (UNFCCC), the United States shares with many countries its ultimate objective: stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. In February 2002, President Bush reaffirmed the Administration's commitment to this long-term goal of the Framework Convention.

There is a growing recognition that climate change cannot be dealt with effectively in isolation. Rather, it needs to be addressed as part of an integrated agenda that promotes economic growth, provides energy security, reduces pollution, and also mitigates greenhouse gas emissions. In July 2005, the G8 leaders, meeting in Gleneagles, Scotland, agreed to a plan of action that interlinked climate change objectives with these other important considerations.

Meeting these complementary objectives will require a sustained, long-term commitment by all nations over many generations. To this end, the President has established a robust and flexible climate change policy that harnesses the power of markets and technological innovation, maintains economic growth, and encourages global participation.

Major elements of this approach include: (1) implementing near-term policies and measures to slow the growth in greenhouse gas emissions; (2) advancing climate change science; (3) accelerating technology development and commercialization; and (4) promoting international collaboration.

From fiscal years 2001 to the end of 2006, the federal government will have devoted nearly $29 billion to science, technology, international assistance, and incentive programs that support climate change objectives, more than any other nation. The President's fiscal year 2007 budget calls for $6.5 billion for climate-related activities.

## NEAR-TERM POLICIES AND MEASURES

In 2002, President Bush set an ambitious but achievable national goal to reduce the greenhouse gas intensity—that is, emissions per unit of economic output—of the U.S. economy by 18 percent by 2012. At the time, the Administration estimated that achieving this commitment would avoid an additional 106 million metric tons of carbon-equivalent emissions in 2012 compared to the Energy Information Administration's *Annual Energy Outlook 2002* business as usual base case projection, and would result in cumulative savings of more than 500 million metric tons of carbon-equivalent emissions over the decade.

To this end, the Administration is now implementing numerous programs—including partnerships, consumer information campaigns, incentives, and mandatory regulations—that are directed at developing and deploying cleaner, more efficient energy technologies, conservation, biological sequestration, geological sequestration and adaptation. For example, the Department of Energy's (DOE) Climate VISION program and the Environmental Protection Agency's (EPA) Climate Leaders and SmartWay Transport Partnership programs work in voluntary partnership with specific commitments by industry to verifiably reduce emissions. The Department of Agriculture (USDA) is using its conservation programs to provide substantial incentives to increase carbon sequestration in soils and trees, and to reduce methane and nitrous oxide emissions, two additional and potent greenhouse gases, from crop and animal agricultural systems. The Department of Transportation (DOT) has implemented a new fuel economy standard for light trucks, including sport utility vehicles, that is projected to result in significant reductions in $CO_2$ emissions over the life of the affected vehicles. DOT has also submitted an Administration proposal to Congress for authority to reform the setting and calculation of fuel economy standards for passenger automobiles.

In terms of financial incentives, new tax rules on expensing and dividends are helping to promote substantial new capital investment, including purchases of cleaner, more efficient equipment and facilities. The Energy Policy Act of 2005 provides for approximately $1.6 billion in tax credits and incentives in fiscal year 2007 to accelerate the market penetration of clean, efficient technologies. For example, the Act also provides tax credits of up to $3,400 for the most highly fuel efficient vehicles such as hybrids and clean diesel. It also establishes 15 new appliance efficiency mandates and a 7.5 billion gallon renewable fuel requirement by 2012.

We expect these efforts will contribute to meeting the President's 18 percent, 10-year goal, which represents an average annual rate of improvement of about 1.96 percent. Data from the Energy Information Administration (EIA) suggest steady progress. Since 2002, EIA reports annual improvements in greenhouse gas emissions intensity of 1.6 percent and 2.1 percent in 2003 and 2004, respectively. Further, a June 2006 EIA preliminary "flash estimate" estimate of energy-related carbon dioxide emissions—which account for about four fifths of total greenhouse gas emissions—shows an improvement in carbon dioxide emissions intensity of 3.3 percent in 2005. Although we are only a few years into the effort, the Nation appears on track to meet the President's goal.

While acting to slow the growth of greenhouse gas emissions in the near term, the United States is laying a strong scientific and technological foundation to reduce uncertainties, clarify risks and benefits, and develop realistic mitigation options through better integration and management of its climate change related scientific and technological activities. In February 2002, President Bush announced the creation of a cabinet-level Committee on Climate Change Science and Technology Integration, co-chaired by the Secretaries of Commerce and Energy. Two multi-agency programs were established to coordinate Federal activities in climate change scientific research and advance the President's vision under his National Climate Change Technology Initiative (NCCTI). These are the U.S. Climate Change Science Program (CCSP), led by the Department of Commerce, and CCTP, led by DOE.

## CLIMATE CHANGE SCIENCE PROGRAM[1]

CCSP is an interagency research planning and coordinating entity charged with investigating natural and human-induced changes in the Earth's global environmental system, monitoring, understanding, and predicting global change, and providing a sound scientific basis for national and international decision-making. CCSP combines the near-term focus of the Administration's Climate Change Research Initiative—including a focus on advancing the understanding of aerosols and carbon sources and sinks and improvements in climate modeling—with the breadth of the long-term research elements of the U.S. Global Change Research Program.

In July 2003, CCSP released its *Strategic Plan* for guiding climate research. The plan is organized around five goals: (1) improving our knowledge of climate history, variability, and change; (2) improving our ability to quantify factors that affect climate; (3) reducing uncertainty in climate projections; (4) improving our understanding of the sensitivity and adaptability of ecosystems and human systems to climate change; and (5) exploring options to manage risks associated with climate variability and change. CCSP is now in the process of implementing its 10-year *Plan*. The President's fiscal year 2007 budget request includes $1.715 billion for the

[1] See: http://www.climatescience.gov.

climate change science. The knowledge gained through CCSP will be invaluable in helping CCTP plan for needed technology development.

## CLIMATE CHANGE TECHNOLOGY PROGRAM[2]

To address the challenges of energy security, economic development, and climate change, there is need for a visionary, long-term perspective. The International Energy Agency estimates there are about 2 billion people who lack modern energy services.  Many countries are focusing efforts on providing power to their citizens. Although projections vary considerably, a tripling of energy demand by 2100 is certainly not unreasonable. When one considers further that energy-related carbon dioxide emissions account for about four fifths of all greenhouse gas emissions, the scale of the challenge becomes apparent.  Most anthropogenic greenhouse gases emitted over the course of the 21st century will come from equipment and infrastructure not yet built, a circumstance that poses significant opportunities to reduce or eliminate these emissions.

As we look to the future, providing the energy necessary to power economic growth and development while at the same time reducing greenhouse gas emissions is going to require cost-effective transformational technologies that can fundamentally alter the way we produce and use energy. Given the huge capital investment in existing energy systems, the desired transformation of the global energy system may take many decades. A robust research effort undertaken today can make new, competitive technologies available sooner rather than later and accelerate modernization of capital stock.

Other greenhouse gases from non-energy related sources—methane, nitrous oxides, sulfur hexafluoride, and fluorocarbons, among others—also pose a concern.  They have higher warming potentials than carbon dioxide.  In aggregate, these gases present a large opportunity to reduce global radiative forcing and, in many cases, the technical strategies to reduce their emissions are straightforward and tractable.  Finding ways to mitigate these other greenhouse gases is an important part of CCTP's technology strategy.

The United States is leading the development of many advanced technology options that have the potential to reduce, avoid, or sequester greenhouse gas emissions. CCTP was created in 2002, and subsequently authorized in Title XVI of the Energy Policy Act of 2005, to coordinate and prioritize the Federal Government's investment in climate-related technology and to further the President's National Climate Change Technology Initiative (NCCTI). The fiscal year 2007 Budget includes nearly $3 billion for CCTP-related activities.

CCTP's principal aim is to accelerate the development and reduce the cost of new and advanced technologies with the potential to reduce, avoid, or sequester greenhouse gas emissions. It does this by providing strategic direction for the CCTP-related elements of the overall Federal technology portfolio. It also facilitates the coordinated planning, programming, budgeting, and implementation of the technology development and deployment aspects of U.S. climate change strategy. CCTP also is assessing different technology options and their potential contributions to

[2] See: http://www.climatetechnology.gov.

reducing greenhouse gas emissions over the short, mid, and long term to help inform budget decisions and priorities.

**STRATEGIC PLANNING FOR TECHNOLOGY DEVELOPMENT:** CCTP conducts its planning under conditions of uncertainty and across a wide range of possible futures. The pace and scope of needed change will be driven partially by future trends in greenhouse gas emissions that are subject to great a deal of ambiguity. The complex relationships among population growth, economic development, energy demand, mix, and intensity, resource availability, technology, and other variables make it impossible to accurately predict future greenhouse gas emissions on a 100-year timescale.

In August 2005, CCTP issued its *Vision and Framework for Strategy and Planning*. This document provides an overall strategy to guide and strengthen our technical efforts to reduce emissions. Shortly thereafter, CCTP released its draft *Strategic Plan* for public review and comment. More than 250 comments were received and addressed. We appreciate the thoughtful comments we received, which have improved the document.

Today, CCTP issues its completed *Strategic Plan*. Building on the guidance in the *Vision and Framework*, the *Strategic Plan* articulates a vision of the role for advanced technology in addressing climate change, defines a supporting mission for CCTP, establishes strategic direction and guiding principles for Federal R&D agencies to use in formulating research and development portfolio, outlines approaches to attain CCTP's strategic goals, and identifies a series of next steps toward implementation.

CCTP's strategic vision has six complementary goals: (1) reducing emissions from energy use and infrastructure; (2) reducing emissions from energy supply; (3) capturing and sequestering $CO_2$; (4) reducing emissions of non-$CO_2$ greenhouse gases; (5) measuring and monitoring emissions; and (6) bolstering the contributions of basic science.

Ten Federal agencies support a broad portfolio of activities within this framework. Participating Federal agencies in CCTP include the Departments of Energy, Agriculture, Commerce, Defense, Health and Human Services, Interior, State, and Transportation, as well as the Environmental Protection Agency, the National Aeronautics and Space Administration, and the National Science Foundation.

The *Strategic Plan* provides a comprehensive, long-term look at the nature of the climate change challenge and its potential solutions.  It defines clear and promising roles for advanced technologies by grouping technologies for near-, mid- and long term deployment. Together these technologies will facilitate meeting CCTP goals. It also outlines a process and criteria for setting priorities by organizing and aligning Federal climate change R&D and discusses in detail the current climate change technology portfolio, with links to individual technology roadmaps and goals. CCTP and the participating agencies periodically conduct and support strategic planning exercises to identify gaps and opportunities in climate change technology and realign the portfolio as appropriate.

The *Strategic Plan* also identifies a number of next steps outlining an ambitious agenda for advancing climate change technology development. These include strengthening the Federal R&D portfolio, intensifying basic research support of the applied technology R&D programs, extending international cooperation, and exploring a number of supporting technology policy mechanisms.

Many CCTP activities build on existing work, but the Administration also has expanded and realigned some activities and launched new initiatives in key technology areas to support the CCTP's goals. The President's NCCTI includes 12 discrete activities that could advance technologies to avoid, reduce, or capture and store greenhouse gas emissions on a large scale. The Administration's budget proposal for fiscal year 2007 included $306 million for these NCCTI priorities.

CCTP anticipates that a progression of advanced technologies will be available and enter the marketplace in the near, mid, and long terms. Figure 1 provides a schematic roadmap for the technologies being pursued under CCTP. Readers wishing a fuller explanation of the technology research described below should consult CCTP's *Research and Current Activities* and *Technology Options for the Near and Long Term* reports, both of which are available on the CCTP web page. Short descriptions of each of the NCCTI priorities are also available on the CCTP web page.

**FIGURE 1. CCTP ROADMAP FOR CLIMATE CHANGE TECHNOLOGY DEVELOPMENT**

**ENERGY USE AND INFRASTRUCTURE:** Improving energy efficiency and reducing greenhouse gas emissions intensity in transportation, buildings, and industrial processes can contribute greatly to overall greenhouse gas emission reductions. In addition, improving the electricity transmission and distribution "grid" infrastructure can reduce greenhouse gas emissions by making power generation more efficient of by providing greater grid access for wind and solar power.

Key research activities include FreedomCAR (Cooperative Automotive Research)[3] program, a cost-shared government-industry partnership that is pursuing fuel cell and other advanced automotive technologies. Advanced heavy-duty vehicles technologies, zero-energy homes and commercial buildings, solid-state lighting, and superconducting wires that virtually eliminate electricity transmission losses are other areas of research that could yield significant emissions reduction.

**ENERGY SUPPLY:** Fossil fuels, which emit $CO_2$ when burned, remain the world's energy supply of choice. A transition to a low-carbon energy future would, therefore, require the availability of cost-competitive low- or zero-carbon energy supply options. When combined with alternative energy carriers—such as electricity and hydrogen—these options could offer the prospect of considerable reductions in greenhouse gas emissions.

Renewable energy includes a range of different technologies that can play an important role in reducing greenhouse gas emissions. The United States invests considerable resources in wind, solar photovoltaics, and biomass technologies. We have made much progress in price competitiveness of many of these technologies, but there still is a need to reduce their manufacturing, operating, and maintenance costs. For example, new biotechnology breakthroughs offer the potential for extensive domestic production of cellulosic ethanol by both improving feedstocks and increasing the efficiency of converting lignocellulosic material to ethanol. DOE's Office of Science has awarded up to $250 million over five years (subject to appropriations) for two new bioenergy research centers to advance the science needed to develop new cellulosic conversion technologies, which could decrease greatly the greenhouse gas emissions from liquid transportation fuels.[4]

There will be a continuing need for portable, storable energy carriers for heat, power, and transportation. Hydrogen is an excellent energy carrier, produces no emissions when used in a fuel cell, and can be produced from diverse sources, including renewables, nuclear, and fossil fuels (which in the latter case could be combined with carbon capture). President Bush's $1.2 billion Hydrogen Fuel Initiative[5] is exploring these production options as well as the infrastructure needed to store and deliver hydrogen economically and safely. It is expected that the research being performed under the program will make possible a commercialization decision by industry in 2015 and possible market introduction of hydrogen fuel-cell vehicles by 2020.

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[3] See: http://www1.eere.energy.gov/vehiclesandfuels/about/partnerships/freedomcar/index.html.
[4] See: http://genomicsgtl.energy.gov/centers/index.shtml
[5] See: http://www.eere.energy.gov/hydrogenandfuelcells/presidents_initiative.html.

The United States has vast reserves of coal, and about half of its electricity is generated from this fuel. Advanced fossil-based power and fuels, therefore, is an area of special interest. The FutureGen[6] project is a 10-year, $1 billion government-industry collaboration—which includes India and the Republic of Korea—to build the world's first near-zero atmospheric emissions coal-fired power plant. This project will incorporate the latest technologies in carbon sequestration, oxygen and hydrogen separation membranes, turbines, fuel cells, and coal-to-hydrogen gasification. This research can help coal remain part of a diverse, secure, and environmentally acceptable energy portfolio well into the future.

Concerns over resource availability, energy security, and air quality as well as climate change suggest a larger role for nuclear power as an energy supply choice. The Generation IV Nuclear Energy Systems Initiative[7] is investigating the next-generation reactor and fuel cycle systems that represent a significant leap in economic performance, safety, and proliferation-resistance. While the primary focus for developing a next-generation reactor is on producing electricity in a highly efficient manner, there is also the possibility of coupling a reactor with advanced technology that would allow for the production of hydrogen. These advanced technologies are being developed under the Nuclear Hydrogen Initiative[8] and could possibly enable the production of hydrogen on a scale to meet transportation needs.

Fusion energy[9] is a way to generate power that, if successfully developed, could be used to produce electricity and possibly hydrogen. Fusion has features that make it is an attractive option from both an environmental and safety perspective. However, the technical hurdles of fusion energy are very high, and with a commercialization objective of 2050, its potential impact would be in the second half of the century.

In his 2006 State of the Union Address, President Bush outlined plans for an Advanced Energy Initiative (AEI).[10] AEI aims to accelerate the development of advanced technologies that could change the way American homes, businesses, and automobiles are powered. AEI is designed to take advantage of technologies that with a little push could play a big role in helping to reduce the Nation's use of foreign sources of energy and its pollution and greenhouse gas emissions. AEI includes greater investments in near-zero atmospheric emissions coal-fired plants, solar and wind power, nuclear energy, better battery and fuel cell technologies for pollution-free cars, and cellulosic biorefining technologies for biofuels production.

**CARBON SEQUESTRATION:** Carbon capture and sequestration is a central element of CCTP's strategy because for the foreseeable future, fossil fuels will continue to be among the world's most reliable and lowest-cost form of energy. A realistic approach, then, is to find ways to "sequester" the $CO_2$ produced when these fuels—especially coal—are used. The phrase "carbon sequestration" describes a number of technologies and methods to capture, transport, and store $CO_2$ or remove it from the atmosphere.

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[6] See: http://fossil.energy.gov/programs/powersystems/futuregen/index.html.
[7] See: http://gen-iv.ne.doe.gov.
[8] See: http://nuclear.gov/hydrogen/hydrogenOV.html.
[9] See: http://www.sc.doe.gov/Program_Offices/fes.htm.
[10] See: http://www.whitehouse.gov/stateoftheunion/2006/energy/index.html.

Advanced techniques to capture gaseous $CO_2$ from energy and industrial facilities and store it permanently in geologic formations are under development. The Department of Energy's core Carbon Sequestration Program[11] emphasizes technologies that capture $CO_2$ from large point sources and store the emissions in geologic formations that potentially could hold vast amounts of $CO_2$.

Terrestrial sequestration—removing $CO_2$ from the atmosphere and sequestering it in trees, soils, or other organic materials—has proven to be a low-cost means for long-term carbon storage. The Carbon Sequestration in Terrestrial Ecosystems consortium, supported by DOE's Office of Science, provides research on mechanisms that can enhance terrestrial sequestration

In 2003, DOE launched a nationwide network of seven Carbon Sequestration Regional Partnerships[12] that include 40 states, four Canadian Provinces, three Indian Nations, and over 300 organizations. The partnerships' main focus is on determining the best approaches for sequestration in their regions, and they also will examine regulatory and infrastructure needs. Small-scale validation testing of 35 sites involving terrestrial and geologic sequestration technologies began in 2005, and will continue until 2009.

**NON-CARBON DIOXIDE GREENHOUSE GASES:** A main component of the U.S. strategy is to reduce other greenhouse gases, such as methane, nitrous oxides ($N_2O$), sulfur hexafluoride ($SF_6$), and fluorocarbons, among others.

Improvements in methods and technologies to detect and either collect or prevent methane emissions from various sources—such as landfills, coal mines, natural gas pipelines, and oil and gas exploration operations—can prevent this greenhouse gas from escaping to the atmosphere.[13] In agriculture, improved management practices for fertilizer applications and livestock waste can reduce methane and $N_2O$ emissions appreciably.

Hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and $SF_6$ are all high global warming potential (High GWP) gases. HFCs and PFCs are used as substitutes for ozone-depleting chlorofluorocarbons and are used in or emitted during complex manufacturing processes. Advanced methods to reduce the leakage of, reuse, and recycle these chemicals and lower GWP alternatives are being explored.

Programs aimed at reducing particulate matter have led to significant advances in fuel combustion and emission control technologies to reduce U.S. black carbon aerosol emissions. Reducing emissions of black carbon, soot, and other chemical aerosols can have multiple benefits, including better air quality and public health and reduced radiative forcing.

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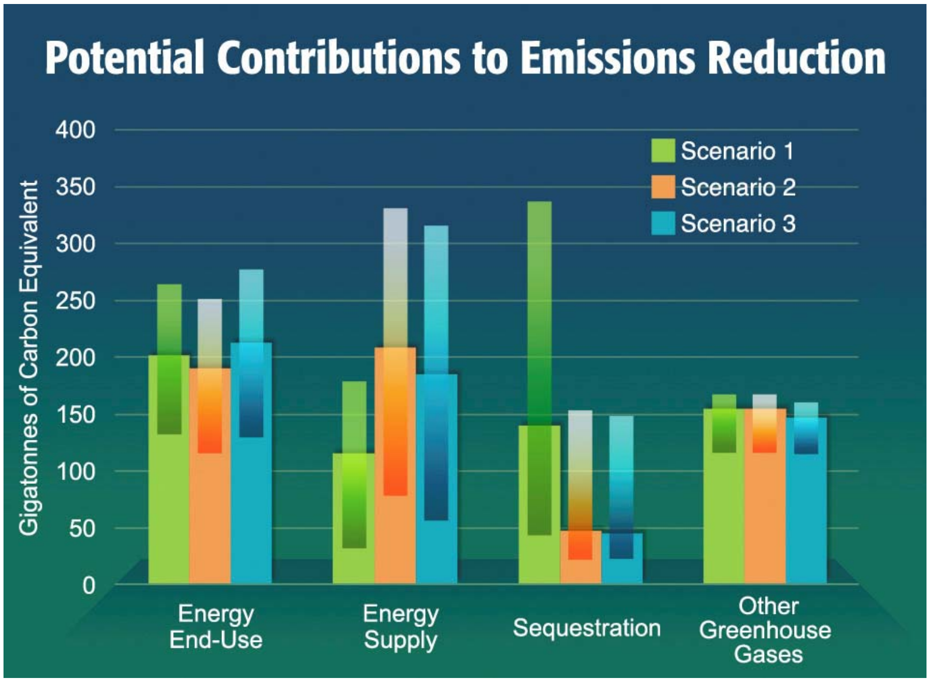
[11] See: http://fossil.energy.gov/programs/sequestration/index.html.
[12] See: http://fossil.energy.gov/programs/sequestration/partnerships/index.html.
[13] Reducing methane emissions may also have a positive benefit in reducing local ozone problems, as methane is an ozone precursor.

**MEASURING AND MONITORING:** To meet future greenhouse gas emissions measurement requirements, a wide array of sensors, measuring platforms, monitoring and inventorying systems, and inference methods are being developed. Many of the baseline measurement, observation, and sensing systems used to advance climate change science are being developed as part of CCSP. CCTP's efforts focus primarily on validating the performance of various climate change technologies, such as in terrestrial and geologic sequestration.

**BASIC SCIENCE:** Basic scientific research is a fundamental element of CCTP. Meeting the dual challenges of addressing climate change and meeting growing world energy demand is likely to require discoveries and innovations that can shape the future in often unexpected ways. The CCTP framework aims to strengthen the basic research enterprise through strategic research that supports ongoing or projected research activities and exploratory research involving innovative concepts.

**SCENARIO ANALYSIS:** CCTP uses scenario analyses that incorporate various assumptions about the future to clarify the potential role of climate change technologies and to aid in portfolio planning. Scenarios analyses can provide a relative indication of the potential climate change benefits of a particular technology mix compared to others, and it can help determine which classes of technology would most likely provide larger-scale benefits. Figure 2 offers a glimpse of the range of emissions reductions new technologies in energy end use, energy supply, carbon sequestration, and other non-$CO_2$ greenhouse gases may make possible on a 100-year scale and across a range of uncertainties and constraints.

**FIGURE 2: POTENTIAL CONTRIBUTIONS TO EMISSIONS REDUCTIONS**



*Potential ranges of greenhouse gas emissions reductions to 2100 by category of activity for three technology scenarios characterized by: viable carbon sequestration (Scenario 1); dramatically expanded nuclear and renewable energy (Scenario 2); and novel and advanced technologies (Scenario 3). Note also the consistently large potential reductions in other greenhouse gas emissions under all three scenarios* (CCTP 2006).

## INTERNATIONAL COLLABORATIONS

The United States believes that well-designed multilateral collaborations focused on achieving practical results can accelerate development and commercialization of new technologies. The U.S. has initiated or joined a number of multilateral technology collaborations in hydrogen, carbon sequestration, nuclear energy, and fusion that address many energy-related concerns (e.g., energy security, climate change, environmental protection).

**Asia-Pacific Partnership on Clean Development and Climate**[14] **(APP):** Launched formally in January 2006, APP is a multi-stakeholder partnership working to generate practical and innovative projects promoting clean development and the mitigation of greenhouse gases. The six APP partnering nations—Australia, China, India, Japan, South Korea, and the United States—account for about half of the world's economy, energy use, and greenhouse gas emissions. APP is pursuing public-private partnerships to build local capacity, improve efficiency and reduce greenhouse gas emissions, create new investment opportunities, and remove barriers to the introduction of clean energy technologies in the Asia Pacific region. At the ministerial launch, the APP partners created eight task forces in the following areas: (1) cleaner fossil energy; (2) renewable energy and distributed generation; (3) power generation and transmission; (4) steel; (5) aluminum; (6) cement; (7) coal mining; and (8) buildings and appliances. Each Task Force is completing an Action Plan that will serve as blueprint for cooperation and provide a strategic framework for identifying and implementing Partnership activities. The President's fiscal year 2007 budget request includes $52 million to support APP.

**INTERNATIONAL PARTNERSHIP FOR THE HYDROGEN ECONOMY (IPHE)**[15]**:** In November 2003, representatives from 16 governments gathered in Washington, DC to launch IPHE, a vehicle to coordinate and leverage multinational hydrogen research programs. Moreover, IPHE will develop common recommendations for internationally-recognized standards and safety protocols to speed market penetration of hydrogen technologies. An important aspect of IPHE is maintaining communications with the private sector and other stakeholders to foster public-private collaboration and address the technological, financial, and institutional barriers to hydrogen.

[14] See: http://www.asiapacificpartnership.org

[15] See: http://www.iphe.net. IPHE members include the United States, Australia, Brazil, Canada, China, European Commission, France, Germany, Iceland, India, Italy, Japan, New Zealand, Norway, Republic of Korea, Russian Federation, and United Kingdom.

**Carbon Sequestration Leadership Forum (CSLF)**[16]**:** CSLF is a U.S. initiative that was established at a ministerial meeting held in Washington, DC, in June 2003. CSLF is a multilateral initiative that provides a framework for international collaboration on sequestration technologies. CSLF has as members 22 governments representing both developed and developing countries.

The Forum's main focus is assisting the development of technologies to separate, capture, transport, and store $CO_2$ safely over the long term, making carbon sequestration technologies broadly available internationally, and addressing wider issues, such as regulation and policy, relating to carbon capture and storage. To date, 17 international research projects have been endorsed by the Forum, five of which involve the United States.

**Generation IV International Forum (GIF)**[17]**:** In July 2001, nine other countries and Euratom joined together under U.S. leadership to charter GIF, a multilateral collaboration to fulfill the objective of the Generation IV Nuclear Energy Systems Initiative. GIF's goal is to develop a fourth generation of advanced, economical, and safe nuclear systems that offer enhanced proliferation-resistance and can be adopted commercially by 2030. Six technologies have been selected as the most promising candidates for future designs, some of which could be commercially ready in the 2020 to 2030 timeframe. GIF countries are jointly preparing a collaborative research program to develop and demonstrate the projects.

**ITER**[18]**:** In January 2003, President Bush announced that the U.S. was joining the negotiations for the construction and operation of the international fusion experiment called ITER. ITER is a proposed multilateral collaborative project to design and demonstrate a fusion energy production system. If successful, this multi-year, multi-billion dollar project will advance progress toward determining whether fusion technology can produce clean, abundant, commercially available energy by the middle of the century.

**Global Nuclear Energy Partnership (GNEP)**[19]**:** GNEP has two major goals: (1) expand carbon-free nuclear energy to meet growing electricity demand worldwide; and (2) promote non-proliferation objectives through the leasing of nuclear fuel to countries which agree to forgo enrichment and reprocessing. A more fully closed fuel cycle model envisioned by this partnership requires development and deployment of technologies that enable recycling and consumption of long-lived radioactive waste. The GNEP initiative proposes international partnerships and significant cost-sharing to achieve these goals.

**Methane to Markets:** The Methane to Markets Partnership is another highly practical major element in the series of international technology partnerships advanced by the Administration.

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[16] See: http://www.cslforum.org. CSLF members include the United States, Australia, Brazil, Canada, China, Colombia, Denmark, European Commission, France, Germany, Greece, India, Italy, Japan, Korea, Mexico, Netherlands, Norway, Russian Federation, Saudi Arabia, South Africa, and United Kingdom.

[17] See: http://gen-iv.ne.doe.gov/GENIVintl-gif.asp. GIF member countries include the United States, Argentina, Brazil, Canada, France, Japan, Korea, South Africa, Switzerland, and United Kingdom.

[18] See: http://www.iter.org. ITER members include the United States, China, EU, India, Japan, Russian Federation, and Republic of Korea.

[19] See: http://www.gnep.energy.gov.

Launched in November 2004, the Methane to Markets Partnership focuses on advancing cost effective, near-term methane recovery and use as a clean energy source from coal beds, natural gas facilities, landfills, and agricultural waste management systems. The Partnership will reduce global methane emissions to enhance economic growth, promote energy security, improve the environment, and reduce greenhouse gas emissions. Other benefits include improving mine safety, reducing waste, and improving local air quality.

### CLOSING OBSERVATIONS

The United States, in partnership with others, has embarked on an ambitious undertaking to develop new and advanced climate change technologies that have the potential to transform the economic activities that give rise to greenhouse gas emissions. CCTP's *Strategic Plan* sets out an overall strategy to guide and strengthen our technical efforts to reduce emissions, articulates a vision of the role for advanced technology in addressing climate change, and provides a long-term planning context in which the nature of both the challenges and the opportunities for advanced technologies are illuminated and balanced.

Innovations can be expected to change the ways in which the world produces and uses energy, performs industrial processes, grows crops and livestock, manages carbon dioxide, and uses land. In keeping with U.S. climate change strategy, which is consistent with the United Nations' Framework Convention, these technologies could both enable and facilitate a gradual shift toward significantly lower global greenhouse gas emissions. They would also continue to provide the energy-related and other services needed to spur and sustain economic growth.

## REFERENCES

CCTP 2006—U.S. Climate Change Technology Program, *Strategic Plan*, Chapter 3, "Synthesis Assessment of Long-term Climate Change Technology Scenarios," (Washington, DC: CCTP). Available at: www.climatetechnology.gov.